DOCUMENT RESUME

ED 030 493 24 PS 002 016

By-Mathews, Mary Elizabeth
Discrimination of Recency in Children. Final Report.
Southern Methodist Univ., Dallas, Tex.
Spons Agency-Office of Education (DHEW), Washington, D.C. Bureau of Research.
Bureau No-BR-8-G-052
Pub Date 28 Feb 69
Grant-OEG-7-8-000052-0064-010
Note-46p.
EDRS Price MF-$0.25 HC-$2.40
Descriptors-*Age Differences, Child Development, Cognitive Processes, *Discrimination Learning, Individual Differences, Kindergarten Children, Mediation Theory, *Memory, Pictorial Stimuli, *Recall (Psychological), Recognition, Socioeconomic Status, Time Factors (Learning)
Identifiers-Discrimination Of Recency, Peabody Picture Vocabulary Test, PPVT

Two experiments comprised this study comparing the ability of children from ages 4 to 12 years to discriminate the order in which items from a previously presented sequence of stimuli had been presented. The hypotheses were that the discrimination of recency (DR) improves with age, that broader separations of test items are easier to discriminate than narrower ones, and that length of the stimulus list influences DR. In experiment one, 76 children were given six test lists of pictorial stimuli. After each list was presented, the subject was shown two of the pictures again and asked to state which one he had seen more recently. The lists consisted of seven or 12 items; either two or four items separated the pictures in question. Experiment two was similar to the first but involved 52 children and increased the separation between items on the testing phase to four and seven. Experiment two was conducted because performances on the first were generally poor. The results from the two experiments showed that DR improved with age and that performance improved when shorter lists and wider separations were used. (WD)

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BR-8-G-052
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PA 24

Final Report

Project No. 8-G-052

Grant No. OEG-7-8-000052-0064-(010)

DISCRIMINATION OF RECENCY IN CHILDREN

Mary Elizabeth Mathews

Southern Methodist University

Dallas, Texas

February 28, 1969

The research reported herein was performed pursuant to a Grant with the Office of Education, U.S. Department of Health, Education and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

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ACKNOWLEDGEMENTS

The author wishes to thank Mrs. Charles Denman, director, Highland Park Presbyterian Day School (Dallas, Texas); Thomas Thomason, principal, Centerville Elementary School (Garland, Texas); Charles Schroeder, director, Kiwanis Day Camp (Dallas); and Mrs. Margaret Rodgers, day school coordinator, Presbyterian Center (Dallas) for their cooperation in allowing the testing of their children. Thanks are also due to Caroleta Melgren for assisting in testing and to Dr. James L. Fozard of the Veterans Administration Outpatient Clinic and the Harvard Medical School, Boston, Massachusetts, and to Professors Virginia Chancey, Robert E. Estes, and Roger Adams of the Southern Methodist University Psychology Department for their suggestions and advice regarding the project. The preliminary research was supported in part by a National Science Foundation Institutional Grant for Science, and in part by National Science Foundation Grant No. GB 5944, both to Southern Methodist University.

Summary

The present research sought to determine if age-related differences exist in the ability of children to distinguish the order of previously presented sequences of stimuli. A measure of discrimination of recency (DR) was employed in which a child was shown a set of colored pictures of familiar objects one at a time. Then, the child was shown pairs of pictures from the set, and was asked to choose the member of each pair that he had seen more recently.

In both experiments conducted, two 7- and four 12-item sets of pictures were employed, and in both, the location of the two question items were either near the beginning or the end of the set. Two questions were asked after the presentation of each set, one involving items near the beginning of the series, the other involving items near the end. Half of the Ss in each age group received one of two random arrangements of the pictures in the sets.

The major difference between the two experiments was in the number of items in the set separating the more and less recent of the two pictures presented in a question. In the first experiment, the separations used were 2 and 4 items. Performance in all age groups was generally poor with these separations, so the experiment was repeated, using separations of 4 and 7 items. The Ss in both experiments were 4 to 12 years old, and in both, Ss in each age group were matched on Peabody Picture Vocabulary Test (PPVT)

scores (an estimate of intelligence), socioeconomic status and educational background.

The results of the two experiments supported the hypothesis that DR improves with age, particularly between ages 8 and 11. With respect to task difficulty, performance improved with shorter lists and wider separations. The arrangement of pictures in the sets influenced DR when the task was difficult. There were no important differences in performance between the first and second question after each set. Locating test items either early or later in the set had little effect on DR. Correlations between DR and the measures of intelligence and socioeconomic status employed were not significant. There were some indications that when S reported reviewing the pictures in a set by saying the names of the pictures to himself, or numbering them, DR was better than when he reported simply looking at them. The implications of the results for future research are considered.

The present experiment compared the ability of children of different ages to discriminate the order in which items from a previously presented sequence of stimuli had been presented. The procedure was adapted from studies of discrimination of recency (DR) by Yntema and Trask (1963) and Fozard and Yntema (1966). In their experiments, a long series of serially presented stimuli was interleaved with questions consisting of pairs of items. Ss chose the member of the pair that they believed had been presented more recently.

Piaget (1955) demonstrated developmental changes in children's temporal concepts by showing that children 7 to 8 years of age could typically recall a story in sequential order, whereas most children 6 to 7 usually recalled the same story without regard to the order of events. Later, Fraisse (1964) suggested that: (a) young children can adapt to succession when temporal and spatial order reinforce each other; and (b) adaptation to succession on a representational level does not develop until later in childhood

Evidence relevant to the first of the suggestions of Fraisse was provided by Pufall and Furth (1966) who found that 4-year-olds were able to learn sequences of geometric forms when presented simultaneously, but not when presented successively. Pufall and Furth interpreted this finding in terms of internal constructs which cannot be created by the 4-year-old but which can be by the 5-year-old. Since Ss manipulated the symbols, temporal qrdering was in effect studied at the sensorimotor rather than at a purely representational level. Atkinson, Hansen, and Bernbach (1964), Hagen and Kingsley (1968), and Hansen (1965) also studied temporal ordering in the context of spatial cues. These investigators presented a succession of animal pictures, laying them face-down, one by one, after showing them. Then, S was asked to identify which picture was a particular animal. The ability to perform this task, particularly when the picture came from early in the series, developed with age.

The present research concerned the hypothesis of Fraisse regarding adaptation to succession at a representational level. It attempted to study temporal ordering when minimal sensorimotor, spatial, or verbal cues were provided to S.

The present research sought to demonstrate that DR would improve with age. More specifically, from work of Hagen and Kingsley (1968) it was expected that items placed closer to the end of the list would be more easily discriminated than those farther

from the question (a recency effect). Fozard and Yntema's (1966) finding, in adults, that broader separations of test items were easier to discriminate than narrower ones was expected to hold for children as well. Finally, the possibility that the length of the stimulus list would influence DR was investigated.

Experiment I

Method

Subjects. Children attending kindergarten classes in Highland Park Presbyterian Day School in Dallas, Texas; first and second grade classes of Centerville Elementary School in Garland, Texas (a suburb of Dallas); and 10 to 12-year-old groups at the YMCA-sponsored Kiwanis Day Camp in Dallas were assigned to five age groups designated 5, 6, 7, 8, and 11. The 76 Ss were drawn from a group of 175 on the basis of similarity of Ss within each group in age, estimates of intelligence, socioeconomic background, previous educational background (see Table 1) and a pretest of the ability to understand the test instructions. Neither Hartley's (F_{max}=2.36) nor Cochran's (C=0.253) tests for homogeneity of variance in age span within the five age groups was significant at the .05 level.

Insert Table 1 about here

To keep the range of intelligence scores the same within each age group, the Peabody Picture Vocabulary Test (PPVT) was used.

Results of t tests showed that the mean I.Q. scores of the age groups were not significantly different, and Hartley's and Cochran's tests for homogeneity of variance showed that the variances of the five groups did not differ significantly.

Measurements of socioeconomic status were based on the fathers' occupation, the status characteristic which Warner and his associates (1949) found to be most highly correlated with the Evaluated Participation Scale measuring social class participation. The scale of fathers' occupations which was used was an elaboration of Warner's scale employed by Hollingshead (1957). The sample was limited to those children whose fathers' occupations were classed in one of the four highest categories of the 7-point scale. The variance of each group on socioeconomic scores was homogeneous according to Hartley's and Cochran's tests.

The variable of previous educational experience was controlled by restricting the sample of first and second graders and Kiwanis Day Camp campers to those who had had at least one full year of kindergarten, and restricting the second graders further, to those children who had spent their first year at Centerville Elementary School. It was not possible to draw Group 11 from Centerville as well, so this group represented students between their fifth and sixth grade years from schools in the Dallas area. No attempt was made to equate the numbers of boys and girls, because their means and variances on the DR scores were not significantly different with-

in any age group or for the entire sample. A pretest described below eliminated seven Ss in Group 5 who showed no understanding of the concept being measured.

Stimuli. The test items were 62 preprimer game cards, picturing common objects such as a table, a ball, or ice cream. They had been selected in pilot work from a set of 72 on the basis of the picture discriminability and the ease with which young children could identify the pictures. The cards were 2x3½ inches and were covered with clear vinyl.

Experimental design. The 62 pictures were divided into six test lists: four 12-item and two 7-item lists. In addition to the test stimuli, there were ten practice stimuli which were arranged randomly into two 3-item and two 2-item lists.

After each test list, two questions were asked. A question consisted of two items from the list and S was to say which he had seen more recently. The two items in a question represented separations of two or four. For the separation of two in 7-item lists (L7), the third and fifth pictures from the beginning of the list were used (L7--3 and 5); for the separation of four, the second and sixth pictures were employed (L7--2 and 6). In the list length 12 (L12), two separations of four were used, pictures 2 and 6 near the beginning of the list (L12--2 and 6), or 7 and 11 near the end (L12--7 and 11). The separations of two in list length 12 involved items 3 and 5 (L12--3 and 5), or 8 and 10 (L12--8 and 10).

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The two questions after each 12-item list were planned so that no picture that appeared in one question was tangential in its location in the list to a picture in the other question; e.g., questions L12--2 and 6 and L12--8 and 10, were combined following two of the 12-item lists, etc. This feature did not occur in the 7-item lists.

For half of the Ss in each age group (Condition 1), the presentation scheme was: L7--3 and 5, L7--2 and 6; L12--8 and 10, L12--2 and 6; L12--3 and 5, L12--7 and 11; L12--2 and 6, L12--8 and 10; L12--7 and 11, L12--3 and 5; L7--2 and 6, L7--3 and 5. For the other half (Condition 2), the order in which the questions were asked following each set was reversed, i.e., L7--2 and 6, L7--3 and 5; L12--2 and 6, etc. In addition to the two orders of presentation, there were also two picture orders, i.e., two separately randomized lists of pictures (Lists A and B). Thus, there were four possible conditions: A-1, A-2, B-1, and B-2. Since Ss were not tested in a specified order, the four conditions were simply alternated, the first S' receiving A-1; the second S' receiving A-2, etc. The number of Ss receiving each testing condition was equal within each age group and equal or proportional between groups.

Procedure. The procedure and instructions employed were developed in pilot studies. Each S was tested individually. He was seated beside E at a table suitable for his size. He was told he would be playing a picture game, and then he was told he would do

some practice sets so that he would know how to play the game. E first showed him two 2-item practice sets. After each set, E laid the two cards before S and asked which of the cards he had seen last. S indicated his answer either verbally or by pointing. For the first set of cards, the earlier-presented card was on the left, and the later-presented card was on the right. For the second picture set, the position of the earlier- and later-presented items was reversed. The last two pretest questions were on 3-item sets. In both questions on these 3-item sets, E showed S the first two pictures and asked which he had seen last. Again, E alternated the positions (left or right) of the earlier- and later-presented items. If S answered any of the pretest questions incorrectly, E corrected him, reviewed the set, and then repeated the question. If S again answered incorrectly, this procedure was repeated, but S was not given another opportunity to answer the question. On the four practice lists, the maximum possible errors was 8. Any S who made four or more errors on this pretest was eliminated and not tested further. The Ss who passed the pretest were then given the discrimination of recency test according to the design described above. E showed the inspection items at a rate of about 1.5 seconds per item. The questions were asked by presenting the two question pictures pasted side by side on a blank white card and asking, "Which of these two pictures did you see last?" The side of the card (left or right) on which a question picture appeared was determined randomly. Knowledge of results was not given during the test. After all testing was completed,

E asked S how he had remembered and been able to answer the questions.

Results

Preliminary analysis showed that DR scores were not different for the first and second questions following picture sets. The raw data and results of this and other preliminary analyses are contained in Appendices A,B,C,D,E,F,G and H.

Comparison of the means and variances of the scores for the first and second questions in each question category revealed no significant differences within any question category or across categories. Neither were significant differences found between the means or variances of Conditions 1 and 2. DR scores on List A were found to be significantly better than those on List B for Group 8, $t(14)=3.66, p<.01$. Although no similar difference between the two randomized lists appeared in any other age group or across age groups, the picture order factor was included in the analyses of variance for further clarification.

Table 2 summarizes the data from Experiment I. Inspection of the data on percentage correct shows that performance was generally poor for all groups on most of the questions, suggesting that the task was more difficult than had been anticipated from pilot work. Two analyses of variance were used to assess the effects of age and separation of items in L7 and L12. L7--3 and 5 and L7--2 and 6 were compared first to the same questions in L12 and second-

ly to L12--8 and 10 and L12--7 and 11. In the first comparison, the separations were equally distant from the beginnings of both lists; in the second, they were equidistant from the ends. Age and picture order were between subject variables; separation of items (2 vs. 4) and list length were within subject variables.

In the comparison of L7 with early separations in L12, significant main effects of age, $F(4,66)=2.97, p<.05$, and list, $F(1,66)=6.78, p<.02$, were found. In the comparison of L7 with late separations in L12, significant main effects of age, $F(4,66)=2.67, p<.05$, and list effects, $F(1,66)=4.06, p<.025$, were again found. Table 2 shows that in both comparisons, performance in Group 5 was the poorest, that in Group 11 the best, with the other groups clustered in between. Also, performance on 7-item lists was better than on 12-item ones.

Insert Table 2 about here

No significant main or interaction effects were found for the amount of separation in the comparison between L7 and early separations in L12; however, a significant main effect of separation was found in the comparison for late separations, $F(1,66)=15.13$, $p<.001$. Table 2 shows that the larger separations were accompanied by higher performance scores than the smaller separations. In the same analysis between L7 and late separations in L12, significant

Age X Separation, $F(4,66)=2.90, p<.05$, and Picture Order X Separation, $F(1,66)=4.45, p<.05$, interactions were found. Table 2 also shows the direction of the first interaction. The larger separations resulted in the greatest performance advantage for Group 5, and the difference between performance at the two separations became progressively less marked for older groups. The separation effect was negligible for Groups 5 and 11. The three-way interaction involving picture order was such that the two picture orders produced greater differences in performance on separations of two than on separations of four. The differences were about equal for the two list lengths, but in different directions.

In addition to this three-way interaction, picture order was involved in another interaction, i.e., list length, in the analysis between L7 and early separations in L12, $F(1,66)=5.09$, $p<.025$. Again, the picture order effect was in different directions for the two list lengths, but this time the effect was more pronounced in L12 than in L7.

In L12, one further analysis of variance was performed to assess the effects of amount and locus of separation (early or late). No main effect was found for age or locus of the separation, but there was a main effect of separation, $F(1,66)=6.14, p<.025$, such that DR performance was better on the larger separations. A significant List X Separation X Locus of Separation interaction, $F(1,66)=4.30, p<.05$, was found. The greatest performance differences

between Lists A and B were for questions L12--8 and 10 and L12--2 and 6. In L12--3 and 5 and L12--7 and 11, the differences in performance between Lists A and B were negligible.

The Pearson product moment correlation coefficient was employed to compare DR and PPVT scores, socioeconomic status; and Spearman rank correlation was employed to compare pretest scores with DR performance within each group. The results showed that none of the correlations were statistically significant at the .05 level of confidence (two-tailed tests).

Experiment II

Because the data on mean fraction correct, reported in Table 2, showed DR performance to be generally poor for all groups on most questions, the discrimination of recency task was made less difficult by increasing the separation between items, and data were obtained on a second group of children.

Method

Subjects. Fifty-two children from the YMCA-sponsored Kiwanis Day Camp were assigned to three groups designated 5, 7, and 12. The matching procedures for I.Q. and socioeconomic status were identical to those used in Experiment I. Since the children at the camp were drawn from all over the Dallas metropolitan area, the previous educational experience varied widely in all age levels. To match Groups 5, 7, and 12 on educational experience, the variances of the three groups around the mean grade level for each group were made as similar as possible. Also, Ss were selected so that

the particular schools represented in each age group were similar. Information regarding age, intelligence, socioeconomic status, and grade levels for Experiment II is summarized in Table 1.

Experimental design. The stimuli, pretest, and procedure were like those in Experiment I. The modifications were made in the question items. The same list lengths were presented in the same order with the following changes: L7--3 and 5 was replaced by L7--1 and 5, a 4-item separation; L12--3 and 5 and L12--8 and 10 were replaced by L12--2 and 9 and L12--4 and 11, a 7-item separation. Except for the substitution of these separations, the order of presentation and counterbalancing was identical to that of Experiment I.

Results

Preliminary analyses for Experiment II were similar to those for Experiment I. Details are contained in Appendices A through H. No significant differences in the mean number correct for first and second questions were found in any question category within or across age groups in either list length. The total variance associated with performance on the first of the two questions following presentation of a list was significantly larger than that for the second, $F_{max}(311)=1.76, p<.01$. Inspection of the data in each cell showed that in the youngest group there was a tendency to perform better on the second of the two questions in the shorter but not in the longer lists. However, chi square tests performed within each age group and list length, and across age groups within each list

length, revealed no significant differences in the frequency distributions of errors on the two questions, so data were combined across questions one and two in later analyses.

No significant differences were found between Conditions 1 and 2 in the means or variances of the DR scores within any age group or across age groups, so these data were combined for the later analyses of variance. One significant difference in mean DR score was found in the comparison of Lists A and B. Within Group 12, the mean DR score on List A was significantly higher, $t(18) = 2.41, p < .05$, than the mean DR score on List B. In Groups 5 and 7, no such difference was found, and the t test revealed no difference when all three groups were considered together. On the basis of the above, Lists A and B were included as a between subjects factor in later analyses of variance in order to assess more thoroughly the effect of picture order on performance.

In contrast to the results of Experiment I, the correlation between the number correct on the pretest and the total number of correct responses on the DR trials was $0.31, p < .05$ (two-tailed test). The correlation was $0.57, p < .05$, for Group 5 and 0.17, $p < .05$, for Group 7. There were so few pretest errors for the oldest group that the correlation was not computed. To further examine the relationship between pretest scores and DR, covariance analysis was performed on the total DR scores in each of the three age groups, using the number correct in the pretest as the predictor. The

significant age effect found for the unadjusted DR scores, $F(2,49)=6.46, p<.005$, was still significant after the adjustment, $F(2,48)=4.80, p<.025$. The results of the analysis must be interpreted with care because the assumption of homogeneity of regression for the three groups was not met.

Table 3 summarizes the data of Experiment II on which the following analyses were based. Conditions L7--1 and 5 and L7--2 and 6 were compared. A significant main effect for age, $F(2,46)=3.91, p<.05$, but not for question, was found. Within the 12-item lists, performance of the three age groups was compared on the

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Insert Table 3 about here

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two separations of items and the locus of these separations, early or late in the list. A significant main effect for age was found, $F(2,46)=7.74, p<.005$. No significant effects for either amount or locus of the separation of question items occurred. There was a significant interaction between the amount of separation and age, $F(2,46)=4.76, p<.025$. The main and interaction effects were primarily the result of the performance of Group 12 which was much superior on the 7-item separation than that of any of the three groups on the 4-item separation. Finally, significant interaction effects of Age X List, $F(2,46)=5.12, p<.025$, List X Separation, $F(1,46)=5.10, p<.05$, and all three variables together, $F(2,46)=3.54$,

$p < .05$, were found. The differential effects of the two versions of the lists, A and B, were more marked for the oldest group and for the 7-item separation.

Two analyses of variance were used to compare separations of 4, in L7 and L12. In the first, L7--2 and 6 was compared with L12--2 and 6. Age and picture order were between subject variables. A significant age effect was found, $F(2,46) = 4.83$, $p < .025$. Table 3 reveals that this age effect was due to the oldest group which performed considerably better than the other two groups on both types of question. Neither question category nor list had any significant effect. In the second analysis, comparing L7--2 and 6, and L12--7 and 11, no age or list effect was found, but there was a significant effect of question types, $F(1,46) = 5.18$, $p < .05$. Table 3 shows that performance on L7--2 and 6 was better than on L12--7 and 11.

None of the possible correlations between total DR scores and the performance on the PPVT and socioeconomic level were significant.

Relaxation of selection criteria. Data from Ss who had been eliminated due to scores on the PPVT, socioeconomic level, or pretest scores which did not match those of the experimental groups were added into the experimental groups for analysis. Thus, 14 Ss were added and analyses similar to those described above were repeated. For analyses within L12, only 10 Ss were added, in order

to keep the number of Ss exposed to each picture order equal within age groups. In the other analyses, this was not done because the picture order factor had not been shown to have a significant effect on DR in the original analyses with the 52 experimental Ss, and the factor was not considered in these analyses.

Results were largely the same as those of the first analyses. Main age effects persisted in the comparisons of: L7--2 and 6 with L12--2 and 6, $F(2,63)=5.37, p<.01$; and within L12, $F(2,56)=8.81, p<.001$. In addition, the three two-way interactions in L12 were still significant and in the same directions: Age X List, $F(2,56)=5.44, p<.01$; Age X Separation, $F(2,56)=3.19, p<.05$; and a List X Separation interaction, $F(1,56)=6.09, p<.025$.

Four effects which were no longer evidenced were: the age effect in the L7--1 and 5, and L7--2 and 6 comparison; the question effect in the L7--2 and 6, and L12--7 and 11 comparison; the Age X List X Question interaction in the L7--2 and 6, and L12--4 and 11 comparison; and the Age X List X Separation interaction in the L12 comparisons.

Comparisons of Experiments I and II. Results from the 128 experimental Ss of Experiments I and II for the conditions that were the same in both experiments (L7--2 and 6, L12--2 and 6, and L12--7 and 11) were compared. A preliminary series of t tests and tests for homogeneity of variance showed that none of the differences in means or variances between comparable combinations

of ages and conditions in the two experiments were significantly different. Hence, the data from the two experiments were combined to obtain an overall test of age, question, and list effects.

Comparison of L7--2 and 6, L12--2 and 6 showed significant main effects of age, $F(2,125)= 6.71, p<.005$, and question, $F(1,125)= 8.28, p<.005$, such that performance on the shorter list was superior to that on the longer. This question effect was not significant when the results of Experiment II were considered alone.

Comparison of L7--2 and 6, and L12--7 and 11 revealed a significant effect of age, $F(2,125)= 4.30, p<.025$, when the two groups were combined although there was none found in Experiment II alone. Also in contrast to the results of the same analysis with Experiment II Ss alone, there was no significant difference between performance in the two question categories.

In the analysis of the 12-item lists, the significant age effect found in the Experiment II data persisted, $F(2,122)= 3.13$, $p<.05$, when data from Experiment I were added. Also consistent with the Experiment II analysis, the locus of the question items in the lists (e.g., L12--2 and 6 vs. L12--7 and 11) was not a significant effect in the combined data. The difference between the two random lists was significant as a main effect, $F(1,122)= 4.72$, $p<.05$, whereas it had not been significant except in interaction in the analyses of Experiment II. The list effect did not interact significantly with the other variables in the combined analysis.

Posttest questions. Comparisons were made among Groups 5, 7, and 12 on the responses to the questions: "How did you remember which came last?" and "Did you just look at the pictures or did you say them to yourself?" In Group 5, only 25% of the subjects reported using any method of remembering the pictures other than looking at them. In Group 7, the proportion was 56%, and in Group 12, 95%. A comparison in Group 7 of the mean DR scores of those subjects using special methods and those not using special methods was significant, $t(14) = 1.78, p < .05$, (one-tailed test), the former's being higher. In Groups 5 and 12, the number was not large enough in the two subsets of Ss to make such a comparison.

Discussion

The basic hypothesis that the ability to discriminate recency increases with age was supported by the significant age effects of the analyses of variance in Experiments I and II. In both of these experiments, which differed primarily in task difficulty, the observed age effects were most pronounced in the comparisons between the oldest age group and all of the younger ones. This finding lends support to the suggestion of Fraisse (1964) that adaptation to succession at a representational level occurs later in development than does adaptation to succession aided by spatial cues. The failure to find large age-related differences in performance among the younger groups in the present study probably reflects the difficulty of the present task. Earlier studies of

remembering sequences employed spatial, sensorimotor, or other cues which may have aided performance (Atkinson et al., 1964; Hagen & Kingsley, 1968; Hansen, 1965; Pufall & Furth, 1966).

Generality of findings. The observed age-related differences do not seem to result from sample or procedure pecularities. (a) Comparisons of equivalent conditions in Experiments I and II showed that the results were replicated with different samples. (b) The age-related differences held up when the data from Ss who had been tested but excluded from the primary analyses were combined with those of the experimental groups. (c) The age effects occurred with two random arrangements of the pictures. (d) The age differences in DR performance seemed independent of the differences in pretest scores.

While the general age-related differences seem established, the magnitude of the effect in different age groups depends on the interrelations of three factors: list length, the separation in the list of the two items given in the question, and the locus of the test items in the list.

List length. In three of the four analyses that compared the same separations in 7- and 12-item lists, there was a significant difference between the two, always favoring the 7-item list. There was no interaction between age and list length in any of the four analyses. It appears that list length has no differential effect on Ss within the ages encompassed in this study.

Separation of items in list. Two analyses revealed a main effect for the separation of test items in Experiment I. In both cases, performance was better for the larger separation. Results of both experiments indicated that the effect of separation was different for the age groups, but the nature of the effect is unclear. In Experiment II, the Age X Separation interaction was such that the separation of 7 improved performance more in Group 12 than in Groups 5 and 7. However, in Experiment I, Ss in the age ranges equivalent to Groups 5 and 7 of Experiment II benefited more than the older Ss from the broader separation--in this case, a 4-item separation. The results of both experiments indicated that Groups 5 and 7 reacted essentially the same to the different separations, whereas Group 12 reacted differently than both. Probably, the effect is related to differences in level of performance between the oldest and the younger groups. Separation of items is typically the most important determiner of task difficulty of DR performance, assuming performance level is not near a chance level (Fozard & Yntema, 1966). To better understand the effects of separation of items, further research is required, in which various separations of items are found which will result in equal performance levels for different age groups.

Locus of test items. The prediction of a recency effect was not supported by the data. In neither experiment was there a main effect for the locus of the separation of question

items, nor any clear indirect evidence of a recency effect. The stronger indirect evidence of Experiment II indicated a primacy effect. Performance on L7--2 and 6 was significantly better than performance on L12--7 and 11, but not better than performance L12--2 and 6. Possibly, the weak primacy effect occurred because the children attended more to the earlier stimuli in a list than to the later ones. Interviews with the Ss suggested this.

Arrangement of pictures. The variable of picture order appears to be closely related to the variables of age, separation, and list length. Previous research has shown that differences in the pairs of pictures used in any single experimental condition can produce results for a particular pair that are different from expectation for that condition because of special features of one or both pictures in a pair (Fozard & Lapine, 1968; Fozard & Yntema, 1966). Tables 2 and 3 show that the two picture orders in this study yielded radically different performance particularly in the more difficult conditions.

Several interactions between picture order and other variables were found in the more difficult tasks. In Experiment I, performance differences on Lists A and B were greater in one analysis on the longer, more difficult list. Also, the differences were greater in another analysis for the smaller, more difficult separations. In the comparison within L12 in Experiment II, there were two relevant interactions. In the Age X Picture Order

interaction, Groups 5 and 7 exhibited greater performance differences between Lists A and B than did Group 12. These were in the same groups which in the main effect for age had been shown to exhibit poorer overall performance than Group 12. The Age X Picture Order interaction was such that the greatest performance differences between Lists A and B were on the larger separation for Groups 5 and 7 and on the smaller separation for Group 12. Again, the trend of Groups 5 and 7 was distinct from that of Group 12. As described earlier, Group 12 was the only group to benefit from the broad separations in the 12-item list, and it is evident from Table 3 that Group 12 showed least susceptibility to picture order in the same separation.

Mediation. Saying the names of pictures, numbering them, or putting them together in some kind of meaningful association occurred more frequently in the older Ss. The use of picture naming, etc., aided DR performance in Group 7 of Experiment II. Together, these findings lend credence to the mediation explanation. The present data, while not conclusive, are consistent with past research on mediation and learning in children, which has shown that mediating links such as prepositions or sentences appeared to aid the children in learning tasks (Davidson, 1964; Hagen & Kingsley, 1968; Kendler & Kendler, 1962; Milgram, 1967; Reese, 1962, 1965; Wong & Blevings, 1966). Jensen and Rohwer (1965) found mediation to aid recall on a paired-associate task, but not on

a serial learning task. Further research controlling the amount and kind of mediation in recency discrimination will be necessary before one can adequately respond to the question of the importance of mediation in serial tasks. Requiring Ss to verbalize the names of the pictures, presenting names with the pictures, or organizing the pictures in meaningful sequences all offer possibilities for studying the effects of mediation on DR.

Individual differences. Previous researchers have noted that I.Q. and socioeconomic status are related to conceptual development (Freeberg & Payne, 1967; Goodnow & Bethon, 1966; Mermelstein & Shulman, 1967). In the present study an attempt was made to minimize these effects as much as possible. The failure to find such relationships in this study probably reflects the limited ranges of I.Q., and socioeconomic status encompassed, as well as the small sample used. There was no way to evaluate the relationship of educational background to DR, as the background of all Ss within any group was held constant as much as possible.

Applications. The primary implications of these findings for educators are the importance of using teaching aids offering spatial or sensorimotor cues in the teaching of sequential material (perhaps by breaking it down into shorter sequences when necessary) with children under 11 or 12, and the encouragement of mediation in children in their dealing with sequential material.

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Table 1

Age, Warner Scale Level, and Intelligence Scores of Groups in Experiments I and II

	Age Groups							
	Experiment I					Experiment II		
	5	6	7	8	11	5	7	12
Age (months)								
M	60.00	71.75	86.45	97.75	134.67	67.75	87.13	144.65
SD	2.17	2.79	2.96	3.10	4.87	4.80	5.93	6.23
Range	56-63	68-77	81-92	93-101	125-142	58-76	80-93	132-155
PPVT Score[a]								
M	108.67	109.56	108.50	109.38	110.67	109.56	106.00	109.45
SD	7.80	7.81	10.46	11.39	8.50	11.98	7.75	11.02
Warner Level								
M	2.17	1.88	2.20	2.13	2.42	3.69	3.88	3.60
SD	0.84	0.96	1.06	1.03	1.16	1.30	1.54	1.19
Grade Level								
M	Jr. Kin.	Sr. Kin.	1.00	2.00	5.83	0.44	2.06	6.70
SD	0.00	0.00	0.00	0.00	0.15	0.51	0.68	0.57
N								
Boys	8	7	10	12	8	13	6	14
Girls	4	9	10	4	4	3	10	6

[a]Peabody Picture Vocabulary Test: M=100, SD=20

Table 2

Experiment I: Percentage of Correct DR Responses for List Conditions A and B by Age Groups

Age Groups	List	N	Questions L7-- 3 and 5	L7-- 2 and 6	L12-- 3 and 5	L12-- 8 and 10	L12-- 2 and 6	L12-- 7 and 11
5	A	6	58	67	50	67	58	42
	B	6	58	50	33	33	25	33
6	A	8	50	81	63	44	56	50
	B	8	63	69	56	31	63	100
7	A	10	35	65	60	50	65	65
	B	10	70	65	75	50	45	70
8	A	8	63	69	44	63	75	88
	B	8	56	69	31	44	38	56
11	A	6	83	67	67	58	75	67
	B	6	92	100	58	50	67	67

Table 3

Experiment II: Percentage of Correct DR Responses for List Conditions A and B by Age Group

Age Groups	List	N	Questions					
			L7--			L12--		
			1 and 5	2 and 6	2 and 6	7 and 11	2 and 9	4 and 11
5	A	8	50	56	63	50	44	56
	B	8	88	75	50	63	75	81
7	A	8	63	69	75	75	63	81
	B	8	56	69	63	63	56	38
12	A	8	85	95	100	65	90	80
	B	8	85	75	60	55	100	80

Appendix A

Raw Data: Experiment I

Conditions by Group	Score Pretest*	Test** L7-- 3&5	2&6	L12-- 3&5	2&6	8&10	7&11	Age(mos)	Sex	PPVT	Warner Scale
5: A-1											
S_1	7	2	2	2	1	1	1	62	M	112	1
S_2	7	1	1	1	2	2	0	62	M	103	1
S_3	8	0	2	0	1	2	0	63	F	118	3
5: A-2											
S_4	6	1	1	0	0	0	1	56	M	113	3
S_5	7	2	2	1	2	1	1	62	M	111	3
S_6	8	1	0	2	1	2	2	60	F	109	2
5: B-1											
S_7	7	1	0	0	1	2	2	60	F	111	3
S_8	8	1	1	0	0	0	1	57	F	96	3
S_9	8	1	2	2	1	0	1	59	M	116	2
5: B-2											
S_{10}	8	1	1	0	0	0	0	61	M	112	2
S_{11}	5	1	1	1	1	1	0	60	M	92	2
S_{12}	7	2	1	1	0	1	0	58	M	111	1
6: A-1											
S_1	8	2	1	2	2	0	1	68	F	117	3
S_2	6	1	1	0	0	1	2	71	M	115	1
S_3	8	1	2	1	2	0	1	76	F	121	1
S_4	7	1	2	1	2	2	1	71	M	113	1
6: A-2											
S_5	8	1	2	2	2	1	1	69	F	95	3
S_6	7	1	2	1	1	1	1	71	F	109	1
S_7	8	1	2	2	0	1	0	74	M	103	1
S_8	8	0	1	1	0	1	1	77	F	102	1
6: B-1											
S_9	7	1	2	1	1	1	2	68	F	109	3
S_{10}	6	1	2	2	1	0	2	72	F	105	2
S_{11}	8	1	1	1	1	1	2	72	F	107	1
S_{12}	8	1	1	1	2	0	2	70	M	109	1
7: A-1											
S_1	7	2	2	1	1	0	0	88	F	106	3
S_2	8	1	1	2	2	2	1	91	F	107	2
S_3	7	0	0	2	1	0	0	85	F	108	1
S_4	8	0	1	0	1	1	2	82	F	104	1
S_5	7	0	1	1	1	1	2	92	M	92	2

Appendix A (Continued)

Conditions by Group	Pretest Score	Test Score L7-- 3&5	2&6	L12-- 3&5	2&6	8&10	7&11	Age(mos)	Sex	PPVT	Warner Scale
7: A-2											
S_6	7	1	2	0	2	2	2	87	F	93	3
S_7	8	1	2	1	1	1	1	86	F	122	3
S_8	7	1	2	2	1	0	2	82	F	114	3
S_9	8	0	1	1	2	2	2	81	F	106	3
S_{10}	7	1	1	2	1	1	1	86	M	133	1
7: B-1											
S_{11}	8	1	1	2	1	0	2	85	M	102	1
S_{12}	8	2	2	2	1	1	2	90	M	112	1
S_{13}	8	2	1	1	1	1	2	85	M	122	4
S_{14}	8	1	2	2	2	2	2	85	M	108	2
S_{15}	8	2	2	1	1	0	1	85	M	106	3
7: B-2											
S_{16}	7	1	0	2	0	1	0	86	F	100	1
S_{17}	8	2	2	2	1	2	1	90	M	125	4
S_{18}	8	1	2	1	2	2	2	89	F	108	2
S_{19}	7	1	1	2	0	0	2	87	M	104	1
S_{20}	8	1	0	0	0	1	0	87	M	98	3
8: A-1											
S_1	8	1	0	0	2	2	2	101	M	93	1
S_2	8	1	2	1	2	2	2	99	F	95	3
S_3	7	1	2	2	2	1	2	100	M	109	4
S_4	8	1	1	2	1	1	2	100	M	120	3
8: A-2											
S_5	7	1	2	0	2	1	0	94	M	114	3
S_6	8	1	1	1	1	1	1	95	M	95	1
S_7	8	2	2	0	1	1	2	94	M	128	1
S_8	8	2	1	1	1	1	1	96	M	95	2
8: B-1											
S_9	8	2	1	0	1	0	2	100	M	116	3
S_{10}	7	1	1	0	1	1	1	98	F	106	2
S_{11}	7	1	2	1	0	1	2	92	M	125	1
S_{12}	8	1	2	1	1	1	1	94	M	111	1
8: B-2											
S_{13}	8	1	1	1	1	1	1	98	F	97	3
S_{14}	8	1	1	1	0	1	1	101	M	116	2
S_{15}	8	1	1	1	2	1	0	101	M	126	1
S_{16}	7	1	2	0	0	1	1	101	F	113	3

Appendix A (Continued)

Conditions by Group	Pretest Score	Test Score L7-- 3&5	2&6	L12-- 3&5	2&6	8&10	7&11	Age(mos)	Sex	PPVT	Warner Scale
11: A-1											
S_1	8	2	2	0	1	1	1	140	M	115	3
S_2	8	1	2	2	1	2	2	132	M	118	3
S_3	6	1	1	2	2	2	1	142	M	118	1
11: A-2											
S_4	8	2	2	2	1	1	1	135	F	94	3
S_5	8	2	1	2	2	0	1	134	M	122	1
S_6	8	2	0	0	2	1	2	136	F	103	1
11: B-1											
S_7	8	2	2	0	0	1	1	125	F	105	1
S_8	8	2	2	2	1	0	0	136	M	106	2
S_9	8	2	2	1	2	2	2	128	M	115	3
11: B-2											
S_{10}	8	2	2	2	2	1	2	132	M	112	3
S_{11}	8	1	2	0	1	1	1	138	F	102	4
S_{12}	8	2	2	2	2	1	2	138	M	118	4

* 8 possible correct

** 2 possible correct

Appendix B

Raw Data: Experiment II

Condition by Group	Pretest*	Test** L7-- 1&5	2&6	Test** L12-- 2&6	7&11	2&9	4&11	Age(mos)	Sex	PPVT	Warner Scale
5: A-1											
S_1	6	0	1	1	1	1	0	66	F	107	3
S_2	7	1	1	1	1	2	1	72	F	105	6
S_3	7	1	1	2	1	1	0	70	F	117	3
S_4	7	1	1	2	1	1	2	62	M	144	2
5: A-2											
S_5	6	1	1	2	0	0	1	66	M	101	3
S_6	8	2	1	0	1	1	2	64	M	111	4
S_7	5	1	1	1	2	0	2	72	M	101	2
S_8	8	1	2	1	1	1	1	68	M	95	3
5: B-1											
S_9	7	0	0	1	1	0	1	68	F	97	6
S_{10}	8	2	2	1	1	2	2	72	M	117	5
S_{11}	8	2	2	1	1	2	2	71	M	105	5
S_{12}	8	2	2	1	1	2	2	58	M	125	2
5: B-2											
S_{13}	8	2	2	1	1	2	2	72	M	109	4
S_{14}	7	2	2	1	2	2	2	65	M	109	3
S_{15}	7	2	1	2	1	0	1	76	M	103	4
S_{16}	8	2	1	0	2	2	1	62	M	107	4
7: A-1											
S_1	7	1	2	2	1	2	2	83	F	112	5
S_2	8	2	1	2	2	1	2	78	M	102	3
S_3	8	1	2	2	2	1	2	91	F	100	6
S_4	8	0	2	0	2	1	1	94	M	102	4
7: A-2											
S_5	8	2	2	2	1	2	2	88	F	100	3
S_6	6	1	0	1	1	1	1	80	F	104	3
S_7	6	1	1	1	2	1	2	81	F	98	5
S_8	8	2	1	2	1	1	1	91	F	116	2
7: B-1											
S_9	8	1	2	1	2	1	1	85	F	104	5
S_{10}	7	2	2	0	1	2	0	80	M	100	1
S_{11}	7	1	0	1	0	1	0	95	F	111	3
S_{12}	8	0	1	2	1	1	2	95	M	109	4

Appendix B (Continued)

Conditions by Group	Pretest	Score Test L7-- 1&5	L7-- 2&6	L12-- 2&6	L12-- 7&11	L12-- 2&9	L12-- 4&11	Age(mos)	Sex	PPVT	Warner Scale
7: B-2											
S_{13}	7	1	1	1	2	1	0	87	F	106	3
S_{14}	6	2	2	2	2	1	2	82	M	112	7
S_{15}	7	1	1	1	1	1	0	94	F	125	4
S_{16}	6	1	2	2	1	1	1	90	M	95	4
12: A-1											
S_1	8	2	2	2	1	2	1	138	M	121	3
S_2	8	2	2	2	1	2	2	141	M	105	3
S_3	8	2	2	2	2	1	2	144	F	109	2
S_4	8	2	2	2	1	2	2	150	F	97	5
S_5	8	1	2	2	2	1	2	151	M	104	4
12: A-2											
S_6	7	2	2	2	1	2	2	132	M	106	2
S_7	6	1	2	2	2	2	2	144	M	102	4
S_8	7	1	2	2	1	2	2	151	M	135	3
S_9	8	2	2	2	1	2	0	145	F	130	3
S_{10}	5	2	1	2	1	2	1	144	M	102	2
12: B-1											
S_{11}	8	2	2	2	0	2	2	136	M	119	4
S_{12}	8	2	1	1	2	2	2	143	F	120	3
S_{13}	8	1	2	1	2	2	1	150	M	94	5
S_{14}	7	2	2	2	1	2	2	150	M	111	6
S_{15}	8	1	1	1	1	2	1	147	M	102	4
12: B-2											
S_{16}	8	2	2	2	0	2	2	155	F	109	3
S_{17}	8	2	1	1	1	2	1	133	F	118	3
S_{18}	8	2	2	0	1	2	1	149	M	99	6
S_{19}	8	2	2	1	2	2	2	147	M	101	4
S_{20}	8	1	0	1	1	2	2	144	M	105	3

* 8 possible correct
** 2 possible correct

Appendix C

Means and Variances of DR Scores for Groups by Sex, Picture Order, and Question Order

Experiment I

Group	Sex		Picture Order		Question Order	
	M	F	List 1	List 2	Condition 1	Condition 2
5:						
N	8	4	6	6	6	6
M	5.88	5.50	6.83	4.67	6.17	5.33
SD^2	6.70	3.85	5.77	3.47	4.17	7.47
6:						
N	7	9	8	8	8	8
M	7.00	7.44	6.88	7.63	7.38	7.13
SD^2	2.33	2.28	3.27	1.12	1.41	3.27
7:						
N	10	10	10	10	10	10
M	7.40	6.90	6.80	7.50	7.20	7.10
SD^2	6.71	5.43	3.51	8.50	5.73	6.54
8:						
N	12	4	8	8	8	8
M	7.08	6.50	8.00	5.88*	7.50	6.38
SD^2	1.72	5.67	2.00	0.70	3.14	1.41
11:						
N	8	4	6	6	6	6
M	9.25	7.00	8.33	8.67	8.33	8.67
SD^2	3.07	2.00	1.47	6.67	3.87	4.27
Total						
N	45	31	38	38	38	38
M	7.31	6.84	7.32	6.92	7.32	6.92
SD^2	4.64	3.81	3.25	5.53	3.74	5.05

*$p < .01$

Mathews

Appendix D

Means and Variances of DR Scores for Groups by Sex, Picture Order and Question Order

Experiment II

Group	Sex		Picture Order		Question Order	
	M	F	List 1	List 2	Condition 1	Condition 2
5:						
N	13	3	8	8	8	8
M	8.33	5.00	6.50	8.63	7.50	7.63
SD^2	3.48	3.33	1.43	6.84	6.29	4.55
7:						
N	6	10	8	8	8	8
M	8.00	7.40	8.50	6.75	7.50	7.75
SD^2	4.40	6.71	4.57	5.64	6.29	5.64
11:						
N	14	6	10	10	10	10
M	9.64	9.67	10.30	9.00	9.90	9.40
SD^2	2.09	1.47	0.68	2.22	1.66	2.04
Total:						
N	33	19	26	26	26	26
M	8.73	7.79	8.58	8.19	8.42	8.35
SD^2	3.71	6.51	4.49	5.28	5.53	4.32

Appendix E

Experiment I: Number of Errors by Question Category for First and Second Questions After a List

Question Category	Groups 5	6	7	8	11	Total
L7--2 and 6						
1	4	4	7	6	2	23
2	6	4	7	4	2	23
L7--3 and 5						
1	5	7	10	4	1	27
2	5	7	9	9	2	32
L12--2 and 6						
1	9	8	8	6	3	34
2	5	5	10	8	4	32
L12--3 and 5						
1	7	10*	8	8	4	37
2	7	3	5	12	5	32
L12--7 and 11						
1	9	2	7	5	4	27
2	6	6	6	4	4	26
L12--8 and 10						
1	6	10	12	8	6	42
2	6	10	8	7	5	36
Total						
1	40	41	52	37	20	190
2	35	35	45	44	22	181

*$t(14) = 2.71, p < .05$.

Appendix F

Experiment II: First Number of Errors by Question Category for and Second Questions After a List

Question Category	Groups 5	7	12	Total
L7--2 and 6				
1	5	6	4	15
2	6	4	2	12
L7--1 and 5				
1	7	8	3	18
2	3	5	3	11
L12--2 and 6				
1	6	4	5	15
2	9	6	3	18
L12--7 and 11				
1	7	5	7	19
2	7	5	9	21
L12--2 and 9				
1	8	6	0	14
2	5	7	2	14
L12--4 and 11				
1	3	7	6	16
2	5	6	3	14
Total				
1	36	36	25	97*
2	35	33	22	90

*$p < .01$

Appendix G

Correlations of PPVT Scale, Socioeconomic Status, and Pretest Scores with DR

Group	PPVT Score and DR	Socioeconomic Status and DR	Pretest and DR	
Experiment I:				
5	0.18	0.30	0.073	0.07
6	0.19	0.45		
7	0.32	0.26	0.411*	0.41
8	-0.04	0.34	0.015	0.015
11	0.45	0.38		
Experiment II:				
5	0.38	-0.14	0.573**	0.57
7	-0.27	0.30	0.168	0.17
12	-0.01	-0.03		

*$p < .05$
**$p < .025$

Appendix H

Means and Variances of Comparable Age Groups and Questions of Experiments I and II

Age Groups	N	Questions L7--2 & 6 Mean	L7--2 & 6 Variance	L12--2 & 6 Mean	L12--2 & 6 Variance	L12--7 & 11 Mean	L12--7 & 11 Variance
5:							
Experiment I	16	1.31	0.36	1.13	0.33	1.13	0.25
Experiment II	28	1.36	0.46	1.04	0.63	1.18	0.60
7:							
Experiment I	16	1.38	0.52	1.38	0.52	1.38	0.37
Experiment II	36	1.36	0.40	1.08	0.42	1.39	0.53
12:							
Experiment I	20	1.70	0.33	1.60	0.36	1.20	0.38
Experiment II	12	1.67	0.42	1.42	0.45	1.33	0.42